Diversification of existing rice (*Oryza sativa*)-based cropping system for sustainable productivity under irrigated conditions

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Received : March 2004

ABSTRACT

A field experiment was conducted during 1998-99 and 1999-2000 at Palampur, to diversify existing rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system. Wheat in rice–wheat sequence was replaced with 1 or 2 crops of oilseeds or vegetables crops, viz. *gobhi sarson* (*Brassica napus* ssp *oleifera* DC var. *annua* L.), *linseed* (*Linum usitatissimum* L.), *toria* (*Brassica campestris* L. ssp. *oleifera* (Metzger) Sinsk. var. *toria*) *potato* (*Solanum tuberosum* L.), *pea* (*Pisum sativum* L.) and *Frenchbean* (*Phaseolus vulgaris* L.). Rice–pea–potato sequence recorded significantly highest rice-equivalent yield with production efficiency as high as 58.38 kg/ha/day. However, rice–pea–Frenchbean gave an additional net returns of Rs 7,110/ha over rice–pea–potato, which were also highest than that of rice–wheat. Land-use efficiency as well as benefit : cost ratio were also highest in rice–pea–Frenchbean. Thus in rice–wheat system, wheat crop can be safely replaced by pea, which can be followed either by potato or Frenchbean.

Key words: Diversification, Productivity, Rice-equivalent yield, Rice–wheat system, Crop sequence

Rice–wheat is the most popular crop sequence of mid-hills of Himachal Pradesh. Though the system has sustained over years, yield stagnation has been reported of late by Nambiar and Abrol (1992). This stagnation in productivity can be attributed mainly to monotony of the system as well as exhaustive nature of the cereal–cereal crop sequence. Since rice is the staple food of this area, one can think of replacing wheat only. Further, inclusion of crops like oilseed and vegetable will improve the economic conditions of small and marginal farmers owing to higher price and or higher volume of their main and by-products. Keeping in view the above facts, present investigation was carried out under, All-India Co-ordinated Research Project on Cropping System Research to evaluate production potential and economic viability of different rice-based cropping sequences.

MATERIALS AND METHODS

A field experiment was conducted during 1998-99 and 1999-2000 at CSR Farm of the Department of Agronomy, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, (32.6°N, 76.3°E at an elevation of 1,290.8 m above mean sea-level). The soil was acidic in reaction (pH 5.7) having 0.63% organic matter and 551.8, 48.5 and 217.5 kg/ha available nitrogen, phosphorus and potassium respectively. The treatments comprised 6 rice-based cropping sequences, viz. rice (cv. ‘RP 2421’)-wheat (cv. ‘Aradhana’), rice–*gobhi sarson* (cv. ‘HPN 1’), rice–*linseed* (cv. ‘Janaki’)- sun hemp, rice–*toria* (cv. ‘Kufri Jyoti’), rice–pea (cv. ‘Arkel’)-potato and rice–pea (cv. ‘Lincoln’)-Frenchbean (cv. ‘Contender’). These sequences were evaluated in randomized block design with 4 replications in a permanently laid-out experiment. The crops were raised with recommended package of practices under irrigated conditions. Rice was transplanted after normal puddling. Sunnhemp crop was grown as a green-manure crop, turned before puddling with a soil-turning plough at pre-flowering stage for decomposition in the field.

Main product as well as by-product of economic importance of different crops of respective cropping sequences were converted to rice-equivalent yield (REY) on the basis of prices prevalent during 1999-2000. The data were pooled over 2 years. Production efficiency was calculated as per method given by Tomar and Tiwari (1990). Intensification in time was measured by calculating values of land-use efficiency, by dividing total duration of a sequence with number of days in a year and expressed as percentage.

RESULTS AND DISCUSSION

System productivity

The total production of a sequence in terms of rice-equivalent yield was significantly higher in rice–pea–po-
tato (196.76 q/ha) than other sequences (Table 1). It was closely followed by rice–pea–Frenchbean. Significantly lowest production (56.25 q/ha) was recorded in rice–gobhi sarson sequence, which was significantly lower even in comparison with existing rice–wheat cropping system of the area. Higher production in former sequences was owing to replacement of wheat with high-volume or high-priced vegetable crops like pea, potato and Frenchbean. Chaudhary et al. (2001) also reported more productivity by replacing wheat in rice–wheat system with vegetables like radish and potato. Despite higher price of oilseed, rice–gobhi sarson could not give rice-equivalent yield even comparable to rice–wheat due to lower yield level and uneconomical by-product of gobhi sarson. Inclusion of green-manure crop of sunnhemp along with rice and oilseed in rice–linseed–sunnhemp could not significantly improve the productivity of cereal–oilseed crop sequence in spite of improved rice yield. Though inclusion of a vegetable crop of potato along with rice and oilseed in rice–toria–potato sequence improved rice-equivalent yield significantly over rice–wheat but it was still significantly lower than rice–vegetable–vegetable sequence. Shah et al. (1999) also recorded lower rice-equivalent yield in rice–oilseed crop sequence as compared to rice–wheat.

Production and land-use efficiency

Production efficiency followed almost similar trend as is followed by total production of different sequences. Rice–pea–Frenchbean sequence in spite of significantly lower rice-equivalent yield and longer duration of field occupation than rice–pea–potato recorded significantly higher production efficiency (58.38 kg/ha/day) mainly because of higher prices of main and by-product of Frenchbean compared to potato. Rice–linseed–sunnhemp while remaining at par with rice–gobhi sarson recorded the lowest production efficiency mainly due to low level of production of oilseed crop. The land-use efficiency was also highest in rice–pea–Frenchbean because the sequence utilized the land most efficiently. Rice–gobhi sarson was most inferior in respect of land use, as the land remained idle for almost 2 months in a year.

**Economics**

The economic indicators indicated that rice–pea–potato and rice–pea–Frenchbean recorded significantly highest net returns compared with the other sequences. In spite of higher rice-equivalent yield, higher cost of cultivation of potato reduced the net returns of rice–pea–potato compared with rice–pea–Frenchbean. Net returns of rice–vegetable–vegetable sequences were considerably higher than cereal–cereal (rice–wheat) sequence. On the contrary, oilseed crop containing rice-based sequences recorded lower net returns than rice–wheat. Hence it is not advisable to replace wheat crop of rice–wheat system with any oilseed crop. Benefit : cost ratio of rice–pea–Frenchbean and rice–pea–potato is also above 2.0 indicating that it is quite safe to replace wheat with 2 crops of vegetables. Rao and Willey (1980) also reported that multiple cropping with legume offer special advantages to farmers and reduce the probability of low income in small and marginal farmers.

It can be concluded that farmers of the area can replace wheat crop of rice–wheat system with pea, a legume crop,....

**Table 1.** Rice-equivalent yield (REY) of crop sequences along with yield of main and by-products of component crops, production and land-use efficiency and economics (pooled data)

<table>
<thead>
<tr>
<th>Crop sequence (duration in days)</th>
<th>Yield (q/ha)</th>
<th>REY (q/ha)</th>
<th>Production efficiency (kg/ha/day)</th>
<th>Land-use efficiency (%)</th>
<th>Cost of cultivation (Rs/ha)</th>
<th>Net return (Rs/ha)</th>
<th>Benefit : cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td>Rabi I</td>
<td>Rabi II</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice–wheat (313)</td>
<td>30.88 (33.75)</td>
<td>28.60 (36.15)</td>
<td>84.45 (47.33)</td>
<td>26.98</td>
<td>85.75</td>
<td>18,415</td>
<td>32,255</td>
</tr>
<tr>
<td>Rice–gobhi sarson (304)</td>
<td>28.72 (36.15)</td>
<td>7.73 (38.48)</td>
<td>56.25 (38.75)</td>
<td>18.50</td>
<td>83.28</td>
<td>19,529</td>
<td>14,191</td>
</tr>
<tr>
<td>Rice–linseed–sunnhemp (357)</td>
<td>34.15 (38.48)</td>
<td>9.86 (38.48)</td>
<td>64.33 (47.33)</td>
<td>18.07</td>
<td>97.80</td>
<td>21,948</td>
<td>16,770</td>
</tr>
<tr>
<td>Rice–toria–potato (342)</td>
<td>32.39 (37.25)</td>
<td>15.27 (37.25)</td>
<td>120.99 (38.69)</td>
<td>35.37</td>
<td>93.69</td>
<td>47,578</td>
<td>25,016</td>
</tr>
<tr>
<td>Rice–pea–potato (337)</td>
<td>30.09 (37.98)</td>
<td>65.62 (38.69)</td>
<td>196.76 (38.69)</td>
<td>58.38</td>
<td>92.32</td>
<td>56,038</td>
<td>62,018</td>
</tr>
<tr>
<td>Rice–pea–Frenchbean (358)</td>
<td>30.45 (37.25)</td>
<td>57.28 (27.08)</td>
<td>185.01 (31.24)</td>
<td>51.67</td>
<td>98.08</td>
<td>41,878</td>
<td>69,128</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>11.88</td>
<td>3.44</td>
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</tbody>
</table>

Yield of by-products

Sale price, 600; wheat (grain), 700; gobhi sarson (grain), 1,600; linseed (grain), 1,400; toria (grain), 1,400; rice (grain), 1,000; Frenchbean (vegetable), 1,000; potato, 300; rice (straw), 175; wheat (straw), 175; pea (straw), 175; Frenchbean (straw), 175
which can be followed either by potato or Frenchbean to augment their economic conditions.

REFERENCES


